



⑫

**EUROPEAN PATENT APPLICATION**

⑳ Application number : **95302501.2**

㉑ Int. Cl.<sup>8</sup> : **C09K 19/02, C09K 19/42,  
C09K 19/44, C09K 19/46**

㉒ Date of filing : **13.04.95**

㉓ Priority : **14.04.94 JP 101960/94**

㉔ Date of publication of application :  
**08.11.95 Bulletin 95/45**

㉕ Designated Contracting States :  
**AT BE CH DE FR GB IT LI LU NL SE**

㉖ Applicant : **CHISSO CORPORATION**  
**6-32, Nakanoshima 3-chome**  
**Kitaku**  
**Osaka (JP)**

㉗ Inventor : **Demus, Dietrich**  
**Veilchenweg 22**  
**D-06118 Halle (DE)**  
Inventor : **Shimizu, Itsuo**  
**27-2, Tatsumidaihigashi 3-chome**  
**Ichiharashi, Chibaken (JP)**  
Inventor : **Torui, Youji**  
**2505-3, Asahigaokacho,**  
**Hanamigawaku**  
**Chibashi, Chibaken (JP)**

㉘ Representative : **Lamb, John Baxter**  
**MARKS & CLERK,**  
**57-60 Lincoln's Inn Fields**  
**London WC2A 3LS (GB)**

㉙ **A nematic liquid crystal composition.**

㉚ A nematic liquid crystal composition having a low viscosity comprises a blend of components Y<sub>1</sub> and Y<sub>2</sub>, each composed of at least one compound, which nematic composition does not form a complex, and is characterized in that components Y<sub>1</sub> and Y<sub>2</sub> have a large difference between their respective heats of vaporization.

This invention relates to a nematic liquid crystal composition used for liquid crystal display elements and use of the composition for electrooptical display elements.

#### Description of the Related Art

Liquid crystals can vary their optical characteristics by impressing voltage thereon; hence they are used as compositions for display elements by making use of the properties. The electrooptical display elements using the liquid crystals have been well known to person of ordinary skill in the art.

As such display elements, element having dynamic scattering effect, TN element having a twisted nematic structure, super-twisted nematic element (STN), guest-host element and super-birefringent effect element (SBE) have been known. Among these elements, the most general display element has a twisted nematic structure based upon Schadt-Helfrich's effect.

Among these liquid crystal display elements of conventional types, particularly, elements based upon twisted nematic cell have recently been increasing its importance. The reason consists in that such elements can be easily driven by small type battery under a relatively low voltage. Further, these display elements have been so far highest ones which can be applied to matrix display element capable of presenting a high information density.

However, in the practical aspect, as to TN cell of matrix display element mode, difficult problems have still been left behind. In order to solve these problems or improve the cell in a better direction, the liquid crystal materials used should be stable chemically and to heat, light and electric field and electromagnetic radiation. Further, the materials should have meso phase within a broad temperature range and a low viscosity, and the characteristics such as electric conductivity, dielectric anisotropy, optical anisotropy, etc. also should correspond to kinds and use application fields of the elements. As to matrix display device, low threshold voltage, broad viewing angle, high contrast, rapid response speed, etc. have been required.

Recently, improvement in the response speed has been particularly required, accompanying the broadened use application fields. The response speed is expressed as follows:

when response time:  $t_{on}$ , rotatory viscosity coefficient:  $\gamma_1$ , cell thickness:  $d$ , threshold voltage:  $V_c$ , impressed voltage:  $V$ , and relaxation time:  $t_{off}$ , then

$$t_{on} = \gamma_1 d^2 / \{ \pi^2 K (V^2 / V_c^2 - 1) \}$$

$$t_{off} = \gamma_1 d^2 / (\pi^2 K)$$

$$K = K_{11} + (K_{33} - 2K_{22}) / 4$$

Namely, the response time is proportional to viscosity.

Reduction in the viscosity expresses shortening of response time.

As to the liquid crystal composition, generally compounds of several kinds or more are mixed to obtain physical properties corresponding to the object. As to the physical properties of the mixture, in the case where the resulting mixture does not form a complex, it has been generally said that the additive property of the physical properties of the respective mixed compounds comes into existence.

Namely, among the physical properties of the mixture, as to the viscosity  $\eta$ , when the viscosities of the components of the mixture are respectively referred to as  $\eta_1, \eta_2, \eta_3, \dots$ , and the mol fractions of the components are respectively referred to as  $X_1, X_2, X_3, \dots$ , then a relationship of  $\eta = X_1\eta_1 + X_2\eta_2 + X_3\eta_3 + \dots$ , wherein  $X_1 + X_2 + X_3 + \dots = 1$ , comes into existence in an ideal state.

However, generally there is a difference between an ideal state and a real state, and when the viscosities in a real state and in an ideal state are respectively referred to as  $\eta_{real}$  and  $\eta_{id}$ , the relationship is expressed by the following equation:

$$\eta_{real} = \eta_{id} + \Delta\eta.$$

As to  $\Delta\eta$ , there are possibilities of  $\Delta\eta < 0$ ,  $\Delta\eta = 0$  and  $\Delta\eta > 0$ , and if  $\Delta\eta < 0$ , a composition having a lowest viscosity is obtained under given conditions. However, according to the present art, conditions affording  $\Delta\eta < 0$  have not yet been clarified. As to the composition forming a complex, for example in the case where it is composed of a compound having -CN group, there has been known a case where it is composed of a compound having -CN group and NH-alkyl group.

(Problem to be Solved by the Invention)

In a nematic composition obtained by blending components  $Y_1$  and  $Y_2$  each containing at least one member of compounds, if the nematic composition does not form a complex, the viscosity of the composition depends upon the viscosities of the respective components and the mol fractions of the respective components. The viscosity of the composition includes a viscosity in a state almost near to the ideal state, a viscosity higher than that in the ideal state and a viscosity lower than that in the ideal state. The object of the present invention

is to provide a composition having a viscosity wherein the viscosity in the real state is lower than that in the ideal state.

In short, the object is to find a condition of  $\Delta\eta < 0$  and obtain a composition having a low viscosity. In addition, the real state refers to a practical state and the ideal state refers to an ideal state wherein an additive property comes into existence.

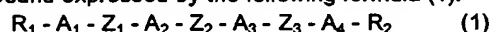
(Means for Solving the Problem)

The present invention has the following constitutions (1) to (11) :

(1) In a nematic liquid crystal composition obtained by blending components  $Y_1$  and  $Y_2$  each containing at least one member of compounds, which nematic composition does not form a complex, a liquid crystal composition having a low viscosity, characterized by blending components  $Y_1$  and  $Y_2$  having a large difference between the vaporization heats of these components.

(2) A nematic liquid crystal composition according to item (1), wherein the difference between the evaporation heats of blended components  $Y_1$  and  $Y_2$  is 800 cal/mol or more.

(3) A nematic liquid crystal composition according to item (1), wherein said components  $Y_1$  and  $Y_2$  each independently are a compound expressed by the following formula (1):



wherein  $R_1$  represents an alkyl group of 1 to 15 carbon atoms, and one or two not adjacent  $CH_2$  groups may be replaced by O, COO, OOC, CO,  $CH=CH$  or  $C\equiv C$ , and hydrogen atom may be replaced by a halogen atom;

$R_2$  represents an alkyl group of 1 to 15 carbon atoms or a halogenated alkyl group or a perhaloalkyl group of 1 to 10 carbon atoms and one or two not adjacent  $CH_2$  groups, CX groups, CHX groups may be replaced by O, COO, OOC or  $CH=CH$  (X represents a halogen), and may be CN, F, Cl, Br or NCS;  $A_1$ ,  $A_2$ ,  $A_3$  and  $A_4$  each represent cyclohexane, cyclohexane wherein one or two not adjacent  $CH_2$  groups may be replaced by O or S, cyclohexene, benzene, benzene wherein one or two hydrogen atoms may be replaced by F, Cl, Br, CN,  $CH_3$  or  $C_2H_5$ , and one or two CH groups may be replaced by N, bicyclooctane, oxadiazole, thiadiazole, thiazole or dioxaborinane, and  $A_3$  and  $A_4$  may be single bond; and  $Z_1$ ,  $Z_2$  and  $Z_3$  each represent single bond,  $CH_2CH_2$ ,  $(CH_2)_4$ ,  $CH=CH$ ,  $C=C$ ,  $CF=CF$ ,  $CHFCHF$ ,  $CF_2CH_2$ ,  $CF_2CF_2$ ,  $CH_2O$ ,  $OCH_2$ , COO or OOC, and when  $A_3$  represents single bond,  $Z_2$  represents single bond, and when  $A_4$  represents single bond,  $Z_3$  represents single bond.

(4) A nematic liquid crystal composition according to item (3) wherein components  $Y_1$  and  $Y_2$  each independently contain at least one member of compounds expressed by the following formula (2):



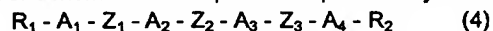
wherein  $R_1$ ,  $R_2$ ,  $A_1$ ,  $A_2$  and  $Z_1$  are as defined in the formula (1)

(5) A nematic liquid crystal composition according to item (3) wherein components  $Y_1$  and  $Y_2$  each independently contain at least one member of compounds expressed by the following formula (3):



wherein  $R_1$ ,  $R_2$ ,  $A_1$ ,  $A_2$ ,  $A_3$ ,  $Z_1$  and  $Z_2$  are as defined in the formula (1), but  $A_3$  does not become a single bond.

(6) A nematic liquid crystal composition according to item (3) wherein components  $Y_1$  and  $Y_2$  each independently contain at least one member of compounds expressed by the following formula (4):



wherein  $R_1$ ,  $R_2$ ,  $A_1$ ,  $A_2$ ,  $A_3$ ,  $A_4$ ,  $Z_1$ ,  $Z_2$  and  $Z_3$  are as defined in the formula (1).

(7) A nematic liquid crystal composition according to item (3) wherein components  $Y_1$  and  $Y_2$  each independently contain at least one member of compounds expressed by the formulas (2) and (3).

(8) A nematic liquid crystal composition according to item (3) wherein components  $Y_1$  and  $Y_2$  each independently contain at least one member of compounds expressed by the formulas (2) and (4).

(9) A nematic liquid crystal composition according to item (3), wherein components  $Y_1$  and  $Y_2$  each independently contain at least one member of compounds expressed by the formulas (3) and (4).

(10) A nematic liquid crystal composition according to item (3) wherein components  $Y_1$  and  $Y_2$  each independently contain at least one member of compounds expressed by the formulas (2), (3) and (4).

(11) An electrooptical display element using the respective compositions of items (1) to (10).

Brief Description of the accompanying drawing:

Fig. 1 shows a view illustrating the viscosity and the mixing proportion of liquid crystal mixture. The constitution and effectiveness of the present invention will be described in more detail.

The viscosity  $\eta$  of the mixture directed to the present invention also applies to the above description. Namely, when the respective viscosities of the mixture-constituting components are expressed by  $\eta_1, \eta_2, \eta_3, \dots$ , and the respective mol fractions of the constituting components are expressed by  $X_1, X_2, X_3, \dots$ , then  $\eta = X_1\eta_1 + X_2\eta_2 + X_3\eta_3 + \dots$ , and  $X_1 + X_2 + X_3 + \dots = 1$ , in the ideal state.

There is a difference between  $\eta$  in the ideal state and  $\eta$  in the real state, and when the viscosities in the real state and the ideal state are expressed by  $\eta_{\text{real}}$  and  $\eta_{\text{id}}$ , then the relation is expressed by the following equation:

$$\eta_{\text{real}} = \eta_{\text{id}} + \Delta\eta.$$

In general, in the case of liquid crystal mixture,  $\Delta\eta > 0$  is basic. However, in the case of a composite substance such as complex or an associated mixture, entirely different behaviors are exhibited. In the case of compositions which are difficult to form a composite substance such as complex or do not cause association, if a composition of  $\Delta\eta < 0$  is obtained, a composition having a low viscosity will be obtained. This is explained referring to Fig. 1.

When a composition  $Y_1$  (viscosity  $\eta_{Y1}$ ) is mixed with a composition  $Y_2$  (viscosity  $\eta_{Y2}$ ) a viscosity  $\eta_{\text{id}}$  in an ideal state is on a linear line connecting  $\eta_{Y1}$  to  $\eta_{Y2}$ , and a viscosity  $\eta_{\text{real}}$  in a real state is fundamentally above the above linear line. Namely, the viscosity in the real state is higher than that in the ideal state. If components  $Y_1$  and  $Y_2$  are chosen so that the viscosity of the mixture may be below the linear line, a composition having a low viscosity is obtained.

In order to effectively lower the viscosity of the composition, namely in order to maximize the value of  $|\Delta\eta|$ , the content of component  $Y_1$  in the composition of mixture of components  $Y_1$  with  $Y_2$  is preferably 20 to 80%, more preferably 30 to 70%.

However, the content is not limited to such a mixing ratio. As can be understood from Fig. 1, when the content is close to 100 %, the  $|\Delta\eta|$  increases. As a result of various researches of a condition where  $\Delta\eta < 0$ , it has been found that if the difference between evaporation heats of two components to be mixed is 800 cal/mol or more, it has been found that the viscosity becomes smaller than that in an ideal state, to obtain a composition having a lowest viscosity. Thus, the present inventors have achieved the present invention.

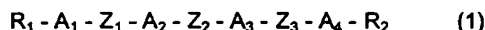
The evaporation heats of the respective components were calculated as follows:

The calculation of the evaporation heats of compounds constituting the respective components relied upon the method Polymer Engineering And Science, Vol. 14, No. 2, 147 (1974).

When the evaporation heats of the respective compounds constituting the components are referred to as  $H_1, H_2, H_3, \dots$ , and the mol fractions of these compounds are referred to as  $X_1, X_2, X_3, \dots$ , then the evaporation heats  $H = H_1 \cdot X_1 + H_2 \cdot X_2 + H_3 \cdot X_3 + \dots$ , wherein  $X_1 + X_2 + X_3 + \dots = 1$ .

When the evaporation heat of component  $Y_1$  and that of component  $Y_2$  are respectively referred to as  $H_{Y1}$  and  $H_{Y2}$ , then when  $|H_{Y1} - H_{Y2}| > 800$  cal/mol, a composition having a viscosity lower than that in the ideal state is obtained.

A suitable composition of the present invention consists of components  $Y_1$  and  $Y_2$ , and the components  $Y_1$  and  $Y_2$  each are composed of at least one kind of compounds of the following formula (1), independently of each other:



(the respective compounds being independent of each other).

In the formula (1),

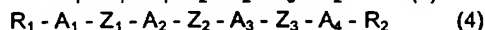
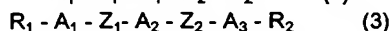
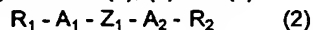
$R_1$  represents an alkyl group of 1 to 15 carbon atoms, and one or two not adjacent  $\text{CH}_2$  groups therein may be replaced by O, COO, OOC, CO,  $\text{CH}=\text{CH}$  or  $\text{C}\equiv\text{C}$  and hydrogen atom may be replaced by halogen atom;

$R_2$  represents an alkyl group of 1 to 15 carbon atoms, a halogenated alkyl or a perhaloalkyl of 1 to 15 carbon atoms, and one or two not adjacent  $\text{CH}_2$ s,  $\text{CX}_2$ s or  $\text{CHX}$ s therein (wherein X represents a halogen) may be replaced by O, CCO, OOC or  $\text{CH}=\text{CH}$  and can be CN, F, Cl, Br or NCS;

$A_1, A_2, A_3$  and  $A_4$  each represent cyclohexane; cyclohexane, one or two not adjacent  $\text{CH}_2$ s in which may be replaced by O or S; cyclohexene; benzene; benzene, one or two H atoms in which may be replaced by F, Cl, Br, CN,  $\text{CH}_3$  or  $\text{C}_2\text{H}_5$ ; benzene one or two CHs in which may be replaced by N; bicyclooctane, oxathiazole, thiadiazole, thiazole or dioxaborane and  $A_3$  and  $A_4$  may be single bond;

$Z_1, Z_2$  and  $Z_3$  each represent single bond,  $\text{CH}_2\text{CH}_2$ ,  $(\text{CH}_2)_4$ ,  $\text{CH}=\text{CH}$ ,  $\text{C}\equiv\text{C}$ ,  $\text{CF}=\text{CF}$ ,  $\text{CHFCHF}$ ,  $\text{CF}_2\text{CH}_2$ ,  $\text{CF}_2\text{CF}_2$ ,  $\text{CH}_2\text{O}$ ,  $\text{OCH}_2$ , COO or OOC, and when  $A_3$  represents single bond, then  $Z_2$  represents single bond, and when  $A_4$  represents single bond, then  $Z_3$  represents single bond.

In more detail, component  $Y_1$  and component  $Y_2$  each are a composition containing at least one kind of compounds expressed by the following formulas (2), (3) and (4):

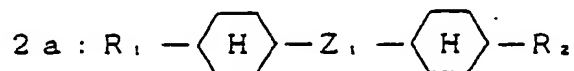


wherein  $R_1$ ,  $R_2$ ,  $A_1$ ,  $A_2$ ,  $A_3$ ,  $A_4$ ,  $Z_1$ ,  $Z_2$  and  $Z_3$  each are as defined above, but, in the formulas (3) and (4),  $A_3$  and  $A_4$  each do not become single bond.

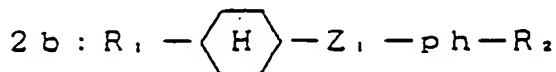
Namely, composition composed of group of compounds of the formula (2), that composed of group of compounds of the formula (3), that composed of group of compounds of the formula (4), that composed of group of compounds of the formulas (2) and (3), that composed of group of compounds of the formulas (2) and (4), that composed of group of compounds of the formulas (3) and (4) and that composed of group of compounds of the formulas (2), (3) and (4), are suitable.

Compounds of the formula (2) include the following compounds:

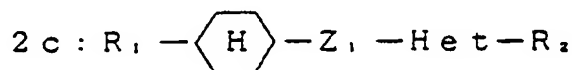
(Compound 1)



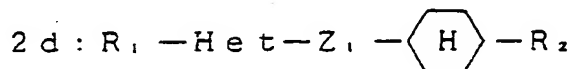
(Compound 2)



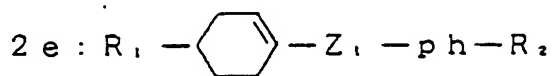
(Compound 3)



(Compound 4)



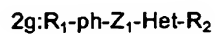
(Compound 5)



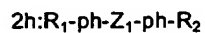
(Compound 6)



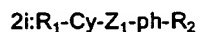
(Compound 7)



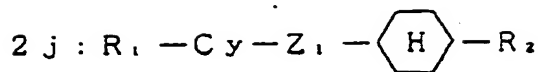
(Compound 8)



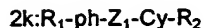
(Compound 9)



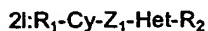
(Compound 10)



(Compound 11)



(Compound 12)



In these compounds,

ph represents benzene, and benzene which may be replaced by one or two F, Cl, Br, CN, CH<sub>3</sub> or C<sub>2</sub>H<sub>5</sub>;

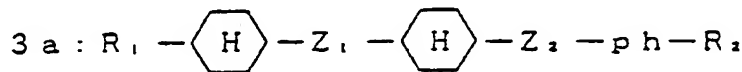
Het represents dioxane, dicyan, pyridine, pyrimidine, pyradine, pyridazine, oxadiazole, thiadiazole, thiazole or dioxaborinan;

Cy represents cyclooctane;

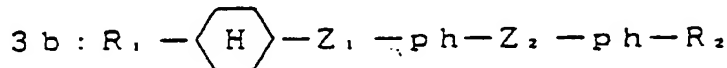
R<sub>1</sub> represents alkyl, alkyloxy, alkyloxyalkyl, alkenyl, alkenyloxy, alkyloxyalkyloxy, alkyloxyalkyloxyalkyl, alkylcarbonyloxy, alkyloxy carbonyl, alkylcarbonyloxyalkyl, alkyloxy carbonylalkyl, alkylcarbonyloxyalkyloxy or alkyloxy carbonylalkyloxy, each of 1 to 15 carbon atoms;R<sub>2</sub> represents alkyl, alkyloxy, alkyloxyalkyl, alkenyl, alkenyloxy, alkyloxyalkyloxy, alkyloxyalkyloxyalkyl, alkylcarbonyloxy, alkyloxy carbonyl, alkylcarbonyloxyalkyl, alkyloxy carbonylalkyl, alkylcarbonyloxyalkyloxy, alkyloxy carbonylalkyloxy, alkylalkyne, alkylalkyneoxy, halogenated alkyl, halogenated alkyloxy, each of 1 to 15 carbon atoms, F, Cl, Br, CN, NCS, CF<sub>3</sub>, OCF<sub>3</sub>, CHF<sub>2</sub> or OCHF<sub>2</sub>; andZ<sub>1</sub> represents single bond, CH<sub>2</sub>CH<sub>2</sub>, (CH<sub>2</sub>)<sub>4</sub>, CH=CH, C≡C, CF=CF, CFHCFH, CH<sub>2</sub>CH<sub>2</sub>, CF<sub>2</sub>CF<sub>2</sub>, CH<sub>2</sub>O, OCH<sub>2</sub>, COO or OOC.

Compounds of the formula (3) include the following compounds:

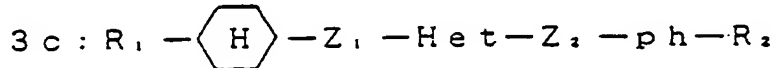
(Compound 13)



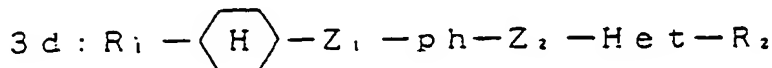
(Compound 14)



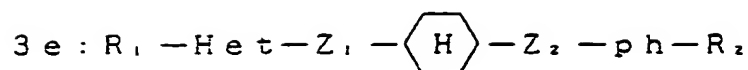
(Compound 15)



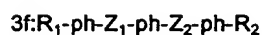
(Compound 16)



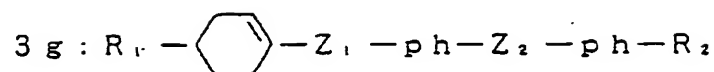
(Compound 17)



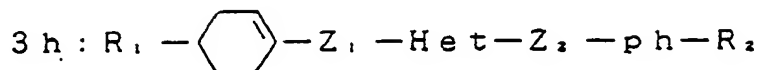
(Compound 18)



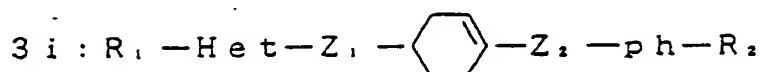
(Compound 19)



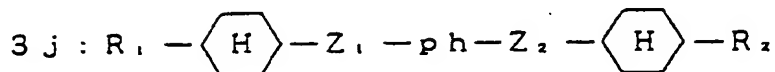
(Compound 20)



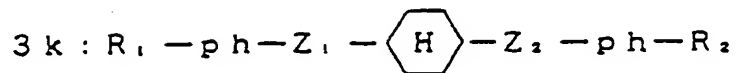
(Compound 21)



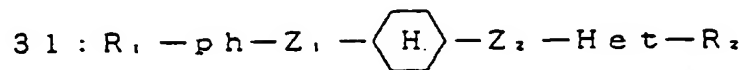
(Compound 22)



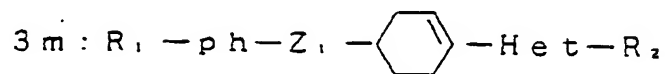
(Compound 23)



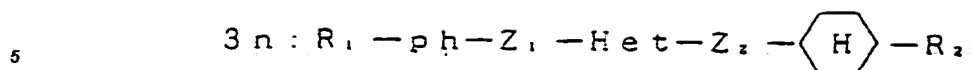
(Compound 24)



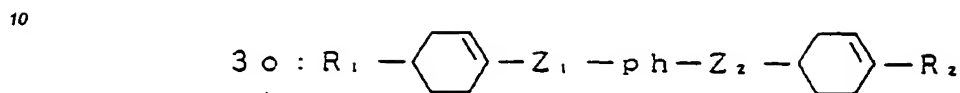
(Compound 25)



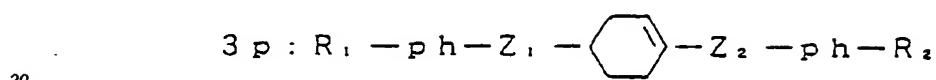
(Compound 26)



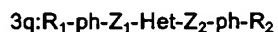
(Compound 27)



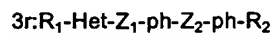
(Compound 28)



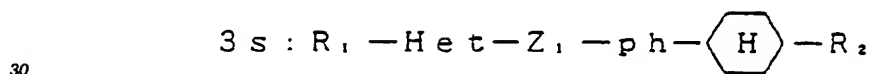
(Compound 29)



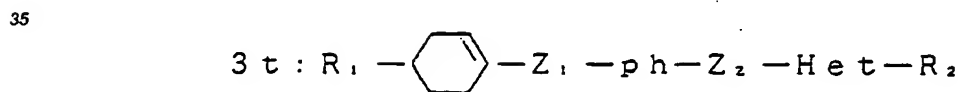
(Compound 30)



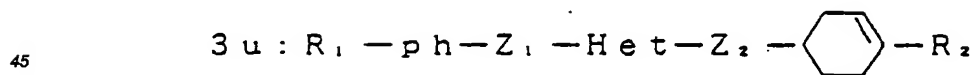
(Compound 31)



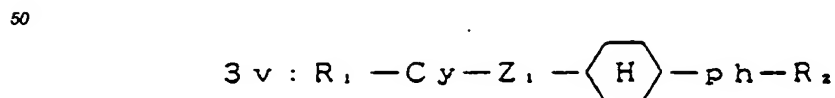
(Compound 32)



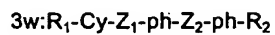
(Compound 33)



(Compound 34)

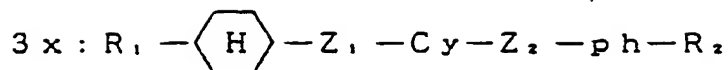


(Compound 35)



(Compound 36)

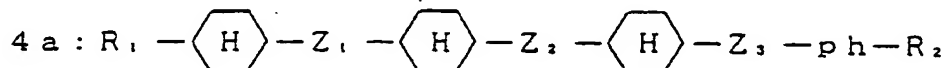




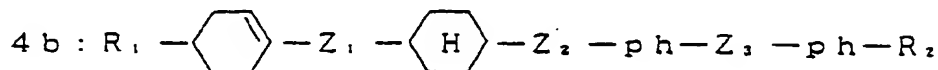
In these formulas,  $R_1$ ,  $R_2$ ,  $Z_1$  and ph are as defined in formulas 2a to 2l, independently of each other,  $Z_2$  and  $Z_1$  are as defined in  $Z_1$  of the above formulas 2a to 2l, independently of each other, and Het and Cy are as defined in formulas 2a to 2l.

Compounds of the formula 4 include the following compounds:

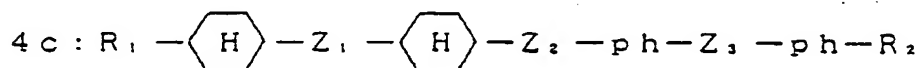
(Compound 37)



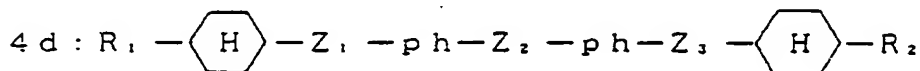
(Compound 38)



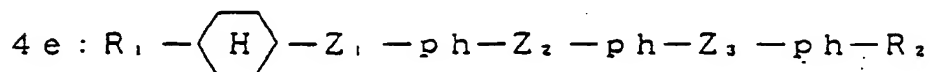
(Compound 39)



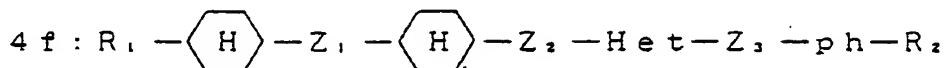
(Compound 40)



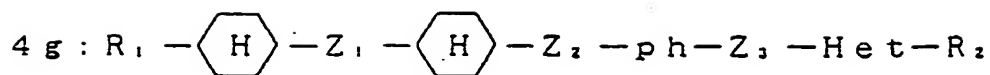
(Compound 41)



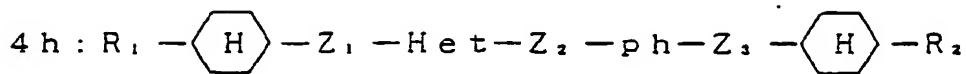
(Compound 42)



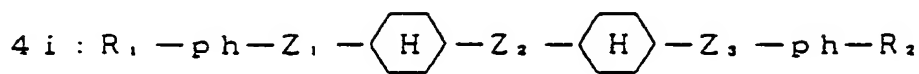
(Compound 43)



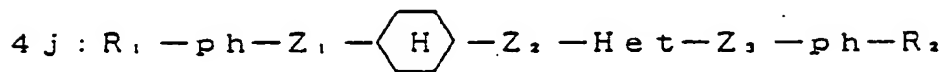
(Compound 44)



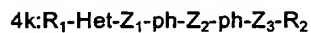
(Compound 45)



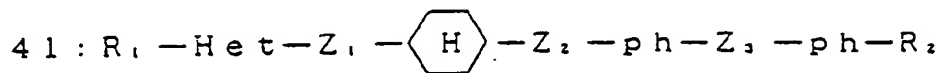
(Compound 46)



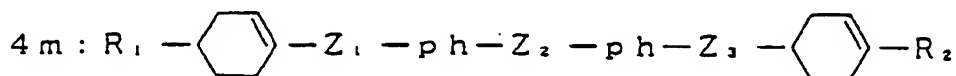
(Compound 47)



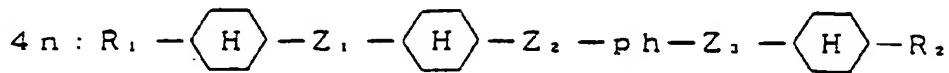
(Compound 48)



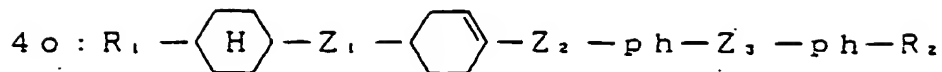
(Compound 49)



(Compound 50)

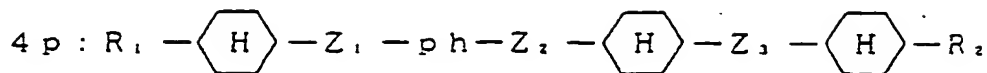


(Compound 51)



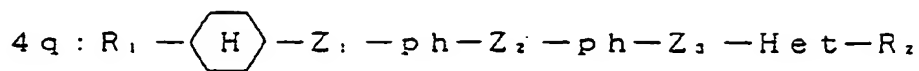
5

(Compound 52)



10

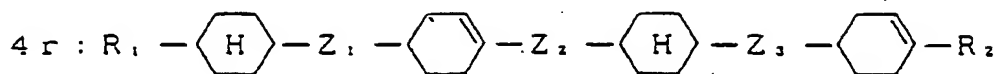
(Compound 53)



15

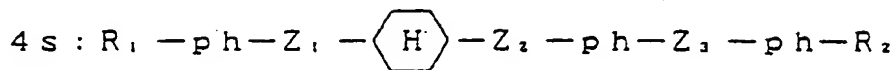
20

(Compound 54)



25

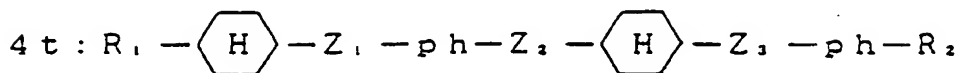
(Compound 55)



30

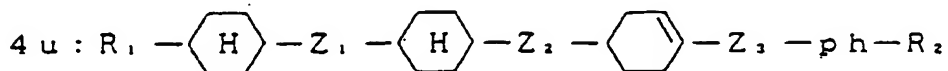
35

(Compound 56)



40

(Compound 57)



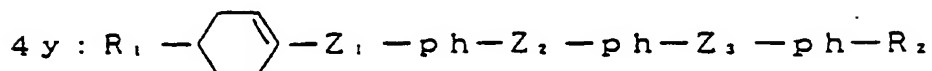
45

50

(Compound 58)



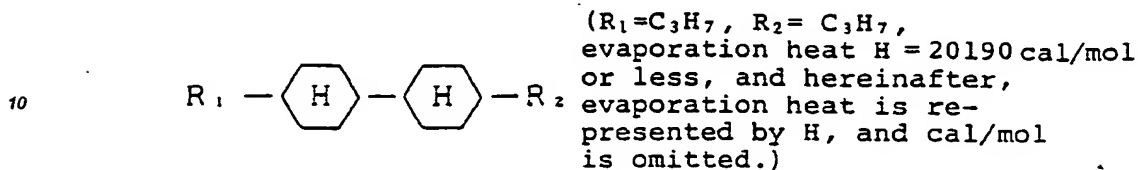
(Compound 59)



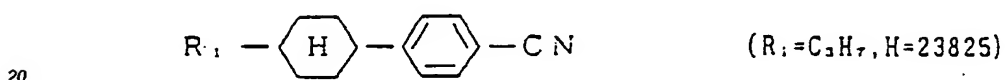
55

In these formulas,  $R_1$ ,  $R_2$ , ph and Het are as defined in the formulas 2a-2l and 3a-3x; and  $Z_3$ ,  $Z_1$  and  $Z_2$  are as defined in  $Z_1$  of 2a to 2l, independently of each other. Concrete examples of these compounds and their evaporation heats are shown below. However, compounds are not limited to these exemplified compounds.

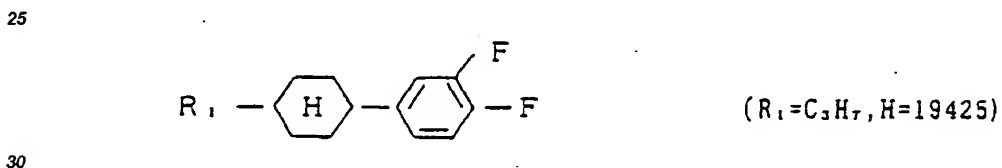
5 (Compound 60)



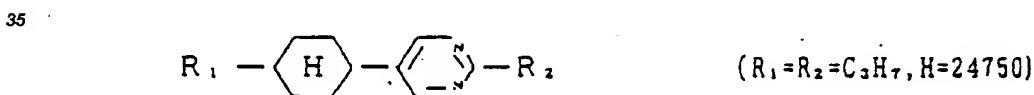
15 (Compound 61)



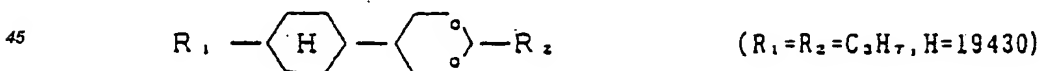
(Compound 62)



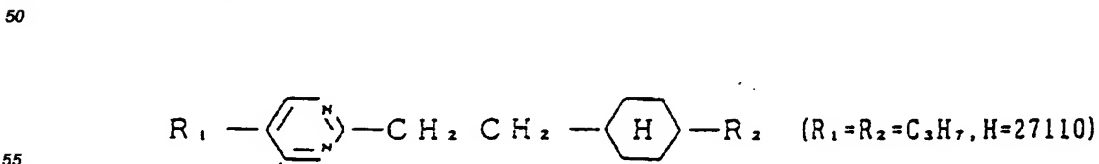
(Compound 63)



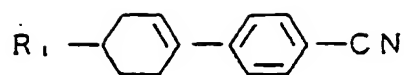
40 (Compound 64)



(Compound 65)

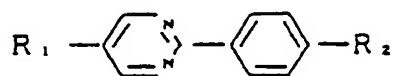


(Compound 66)



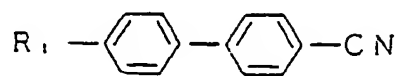
( $R_1 = \text{C}_3\text{H}_7$ ,  $H=23885$ )

(Compound 67)



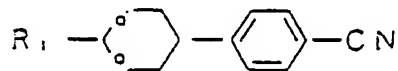
( $R_1 = R_2 = \text{C}_3\text{H}_7$ ,  $H=25770$ )

(Compound 68)



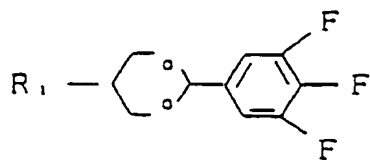
( $R_1 = \text{C}_3\text{H}_7$ ,  $H=24845$ )

(Compound 69)



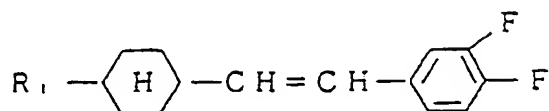
( $R_1 = \text{C}_3\text{H}_7$ ,  $H=23065$ )

(Compound 70)



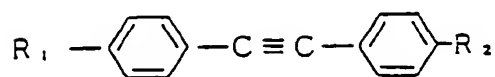
( $R_1 = \text{C}_3\text{H}_7$ ,  $H=18615$ )

(Compound 71)



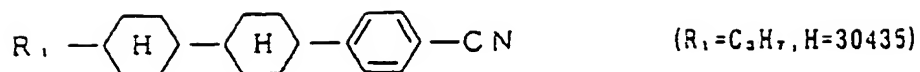
( $R_1 = \text{C}_3\text{H}_7$ ,  $H=21485$ )

(Compound 72)

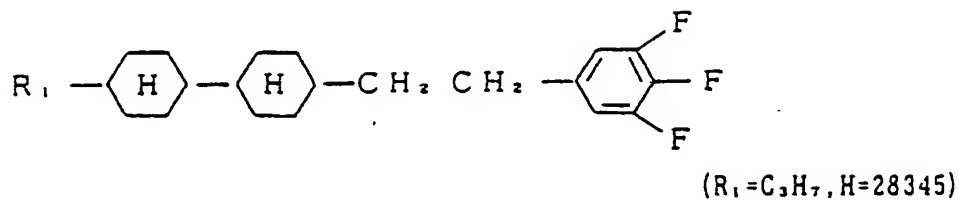


( $R_1 = R_2 = \text{C}_3\text{H}_7$ ,  $H=25610$ )

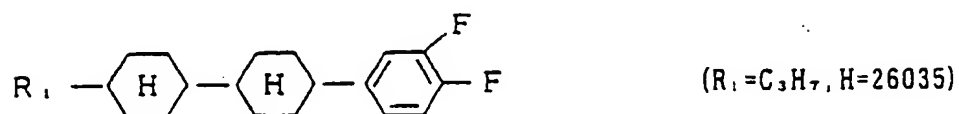
(Compound 73)



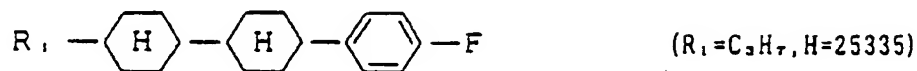
(Compound 74)



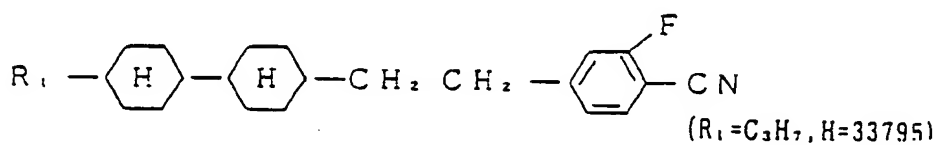
20 (Compound 75)



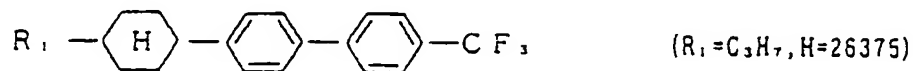
30 (Compound 76)



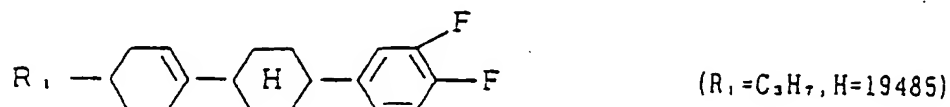
(Compound 77)



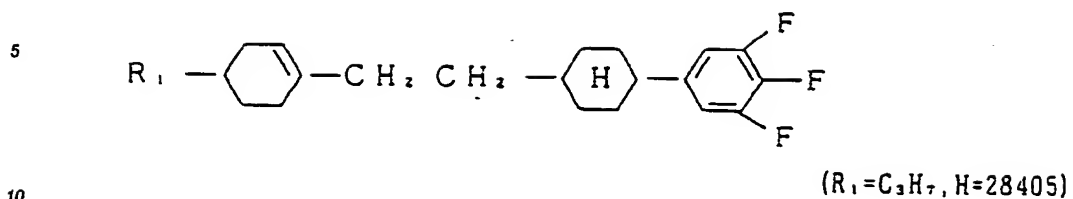
(Compound 78)



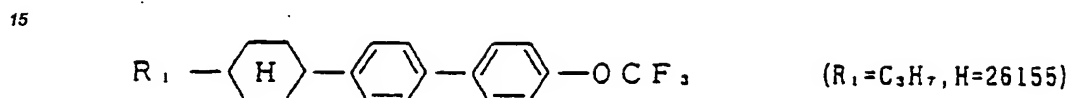
(Compound 79)



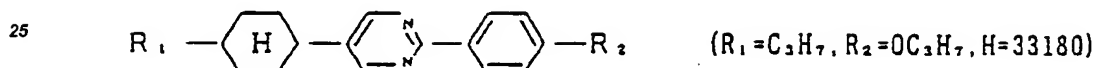
(Compound 80)



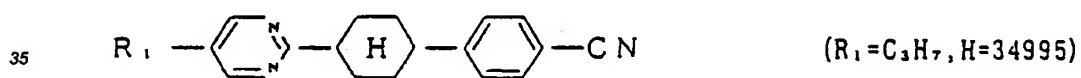
(Compound 81)



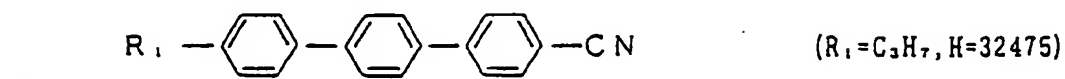
(Compound 82)



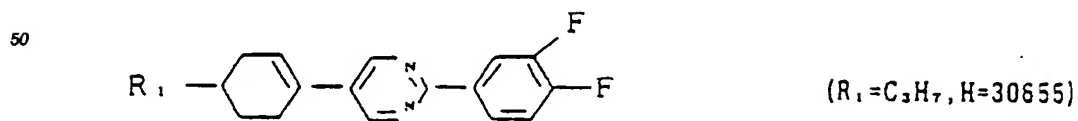
(Compound 83)



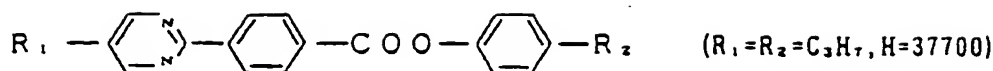
(Compound 84)



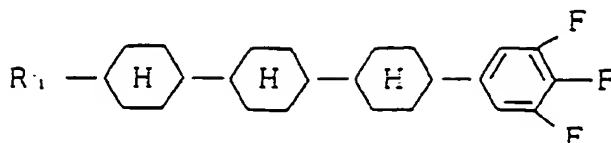
(Compound 85)



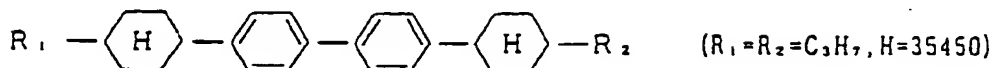
(Compound 86)



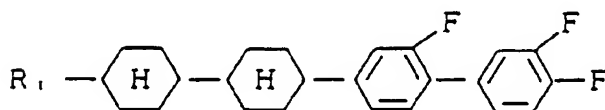
(Compound 87)

(R<sub>1</sub> = C<sub>3</sub>H<sub>7</sub>, H = 32595)

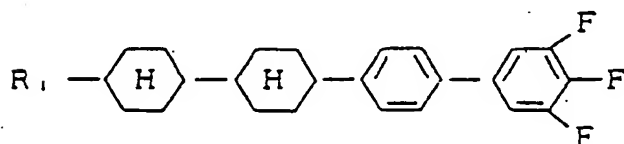
(Compound 88)



(Compound 89)

(R<sub>1</sub> = C<sub>3</sub>H<sub>7</sub>, H = 34665)

(Compound 90)

(R<sub>1</sub> = C<sub>3</sub>H<sub>7</sub>, H = 33615)

45 The present invention will be described by way of Examples, but it should not be construed to be limited thereto.

#### Example 1

50 As to composition A having a measured viscosity value at 20°C of 24.8 cp, its evaporation heat was calculated according to a method of Robert F. Fedors (Polymer Eng. and Sci., Vol. 14, No. 2, 147 (1974)) (this applies to the succeeding evaporation heats), to obtain H<sub>y1</sub> = 27215 cal/mol. As to composition B having a measured viscosity value at 20°C of 10.7 cp, its evaporation heat was H<sub>y2</sub> = 22010 cal/mol. When composition A was mixed with composition B in an equimolar ratio (1:1), the resulting  $\eta_{\text{real}}$  was 16.1 cp.

55 When the compositions A and B each were presumed to be an ideal liquid and the viscosity of a mixed composition of compositions A and B in a ratio of 1:1 was calculated (presuming that the additive property comes into existence),  $\eta_{\text{id}}$  = 17.75 cp was obtained. The difference between the evaporation heat of composition A and that of composition B was  $|H_{y1} - H_{y2}| = 5202$  cal/mol and the difference between the viscosity in the real



state and that in the ideal state was  $\Delta\eta = -1.65$  cp. (Note: the components of the compositions A and B are shown in Examples 2 to 6.)

Examples 2 to 6

5

As shown in the following Table 1, compositions of each two kinds were mixed, followed by measuring the respective viscosities and then calculating the difference between the respective evaporation heats,

10

15

20

25

30

35

40

45

50

55

Table 1

Exam- ple	Kind of compo- sition	Mixing ratio	Viscosity	Evaporation heat	Viscosity of mixed composi- tion, $\eta_{real}$	Ideal viscosity $\eta_{id}$	Reduction in viscosity $\Delta\eta$	Difference between evaporation heats $ H_{y1}-H_{y2} $
2	C+D	1:1	C=21.2* D=12.5*	C=28385 D=23160	13.4*	16.85	-3.45	5225
3	E+D	1:1	E=14.1* D=12.5*	E=26415 D=23160	10.3*	13.3	-3.0	3255
4	C+A	1:1	C=31.7 A=25.1	C=28385 A=27215	24.8	28.4	-3.6	1170
5	E+A	1:1	E=14.7		17.0	19.9	-2.9	800
6	B+F	1:1	B=10.7 F=38.2	B=22010 F=28379	19.7	24.45	-4.75	6369

Symbol \* indicates viscosity cp at 30°C, and others indicate viscosity at 20°C.

Table 2

5	A: $C_6H_5 - \text{C}_6H_4 - \text{C}_6H_4 - \text{C}_6H_3F - F + C_6H_5 - \text{C}_6H_4 - \text{C}_6H_4 - \text{C}_6H_3F - F$ 50 mol %
10	B: $C_6H_5 - \text{C}_6H_4 - O - C_6H_5 + C_6H_5 - \text{C}_6H_4 - O - C_6H_5$ 50 mol %
15	C: $C_6H_5 - \text{C}_6H_4 - \text{C}_6H_4 - CN + C_6H_5 - \text{C}_6H_4 - \text{C}_6H_4 - CN$ 50 mol %
20	D: $C_6H_5 - \text{C}_6H_4 - \text{C}_6H_4 - COOCH_3 + C_6H_5 - \text{C}_6H_4 - \text{C}_6H_4 - COOCH_3$ 50 mol %
25	E: $C_6H_5 - \text{C}_6H_4 - COO - \text{C}_6H_4 - F + C_6H_5 - \text{C}_6H_4 - COO - \text{C}_6H_4 - F$ 50 mol %
30	F: $C_6H_5 - O - \text{C}_6H_4 - \text{C}_6H_3N - C_6H_5 + C_6H_5 - O - \text{C}_6H_4 - \text{C}_6H_3N - C_6H_5$ 14.0 mol %                      21.2 mol % $C_6H_5 - O - \text{C}_6H_4 - \text{C}_6H_3N - C_6H_5 + C_6H_5 - O - \text{C}_6H_4 - \text{C}_6H_3N - C_6H_5$ 23.3 mol %                      41.5 mol %

35

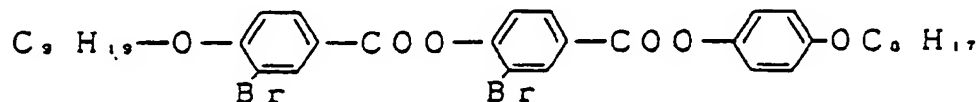
Example 7

The viscosity of composition G at 67°C shown in Table 3 mentioned below was 13 cp and the evaporation heat was 33085 cal/mol.

40

With this composition (50 mol %) was mixed a compound

45



50

(viscosity: 457 cp at 67°C, evaporation heat: 60413 cal/mol) (50 mol%). The observed value of the viscosity of this mixture was 72.7 cp at 67°C. Since the viscosity in the ideal state is 235 cp at 67°C, the difference between the observed value and the ideal value was -162.3 cp. The difference between the evaporation heats was 27328 cal/mol.

The components of the composition G are described in the following Table 3:

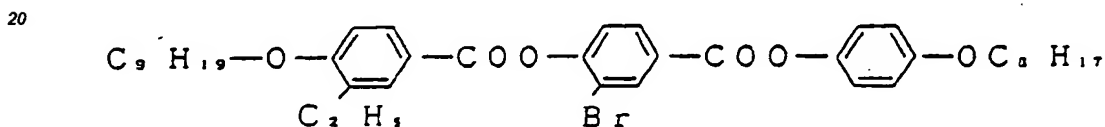
55

Table 3

5	$\text{CH}_3 - \text{O} - \text{C}_6\text{H}_4 - \text{COO} - \text{C}_6\text{H}_4 - \text{OC}_6\text{H}_{13}$	24 mol %
	$\text{C}_6\text{H}_{11} - \text{O} - \text{C}_6\text{H}_4 - \text{COO} - \text{C}_6\text{H}_4 - \text{OC}_6\text{H}_{17}$	27 mol %
10	$\text{C}_6\text{H}_{13} - \text{O} - \text{C}_6\text{H}_4 - \text{COO} - \text{C}_6\text{H}_4 - \text{OC}_7\text{H}_{15}$	12 mol %
	$\text{C}_6\text{H}_{13} - \text{C}_6\text{H}_4 - \text{COO} - \text{C}_6\text{H}_4 - \text{O} - \text{C}_6\text{H}_{17}$	37 mol %

## Example 8

With the composition G (89 mol%) was mixed a compound



25 (viscosity: 145.8 cp at 67°C, evaporation heat: 60413 cal/mol) (11 mol%).

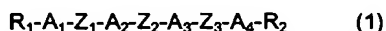
The observed value of the viscosity of this mixture is 18.9 cp at 67°C and the viscosity in the ideal state at 67°C is 27.6 cp. The difference between the observed value and the ideal value was -8.7 cp and the difference between the evaporation heats was 27328 cal/mol.

30 Effectiveness of the Invention:

As described in the above Examples, in the case of a nematic liquid crystal composition obtained by mixing component Y<sub>1</sub> with component Y<sub>2</sub>, each containing at least one compound, which composition does not form any complex, when components Y<sub>1</sub> and Y<sub>2</sub>, the difference of the evaporation heats of which is 800 cal/mol or more, were mixed, then it has been possible to provide a composition having a viscosity lower than the viscosity of the composition in the ideal state.

## Claims

1. A nematic liquid crystal composition comprising a blend of components Y<sub>1</sub> and Y<sub>2</sub>, each composed of at least one compound, which nematic composition does not form a complex and is characterized in that components Y<sub>1</sub> and Y<sub>2</sub> have a large difference between their respective heats of vaporization.
2. A composition according to claim 1, wherein the difference between the heats of evaporation of components Y<sub>1</sub> and Y<sub>2</sub> is 800 cal/mol or more.
3. A composition according to claim 1 wherein components Y<sub>1</sub> and Y<sub>2</sub> are each independently a compound of the formula:



wherein R<sub>1</sub> represents a C<sub>1</sub>-C<sub>15</sub> alkyl group and one or two non-adjacent CH<sub>2</sub> groups may be replaced by O, COO, OOC, CO CH=CH or C=C, and hydrogen may be replaced by a halogen;

R<sub>2</sub> represents a C<sub>1</sub>-C<sub>15</sub> alkyl or a C<sub>1</sub>-C<sub>10</sub> halogenated alkyl group or a C<sub>1</sub>-C<sub>10</sub> perhaloalkyl group and one or two non-adjacent CH<sub>2</sub> groups or CX<sub>2</sub>, CHX groups (in which X represents a halogen atom) may be replaced by O, COO, OOC or CH=CH (X), and/or may be substituted by CN, F, Cl, Br or NCS; A<sub>1</sub>, A<sub>2</sub>, A<sub>3</sub> and A<sub>4</sub> each represent cyclohexane rings, cyclohexane rings wherein one or two non-adjacent CH<sub>2</sub> groups may be replaced by O or S, cyclohexene rings, benzene rings, benzene rings wherein one or two hydrogen

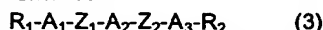
atoms may be replaced by F, Cl, Br, CN, CH<sub>3</sub> or C<sub>2</sub>H<sub>5</sub>, and one or two CH groups may be replaced by N, bicyclooctane rings, oxadiazole rings, thiadiazole rings, thiazole rings or dioxaborinane rings, and A<sub>3</sub> and A<sub>4</sub> may be a single bond; and Z<sub>1</sub>, Z<sub>2</sub> and Z<sub>3</sub> each represent a single bond, CH<sub>2</sub>CH<sub>2</sub>, (CH<sub>2</sub>)<sub>4</sub>, CH=CH, C≡C, CF=CF, CHFCHF, CF<sub>2</sub>CH<sub>2</sub>, CF<sub>2</sub>CF<sub>2</sub>, CH<sub>2</sub>O, OCH<sub>2</sub>, COO or OOC; and when A<sub>3</sub> represents a single bond, Z<sub>2</sub> represents a single bond; and when A<sub>4</sub> represents a single bond, Z<sub>3</sub> represents a single bond.

4. A nematic liquid crystal composition according to claim 3, wherein components Y<sub>1</sub> and Y<sub>2</sub> each independently contain a compound of the formula:



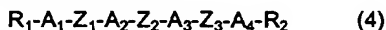
wherein R<sub>1</sub>, R<sub>2</sub>, A<sub>2</sub> and Z<sub>1</sub> are as defined above.

5. A nematic liquid crystal composition according to claim 3, wherein components Y<sub>1</sub> and Y<sub>2</sub> each independently contain a compound of the formula:



wherein R<sub>1</sub>, R<sub>2</sub>, A<sub>1</sub>, A<sub>2</sub>, A<sub>3</sub>, Z<sub>1</sub> and Z<sub>2</sub> are as defined above, but A<sub>3</sub> is not a single bond.

6. A nematic liquid crystal composition according to claim 3, wherein components Y<sub>1</sub> and Y<sub>2</sub> each independently contain a compound of the formula:



wherein R<sub>1</sub>, R<sub>2</sub>, A<sub>1</sub>, A<sub>2</sub>, A<sub>3</sub>, A<sub>4</sub>, Z<sub>1</sub>, Z<sub>2</sub> and Z<sub>3</sub> are as defined above.

7. A nematic liquid crystal composition according to claim 5 wherein components Y<sub>1</sub> and Y<sub>2</sub> each independently contain at least one compound of formulae (2) and (3).

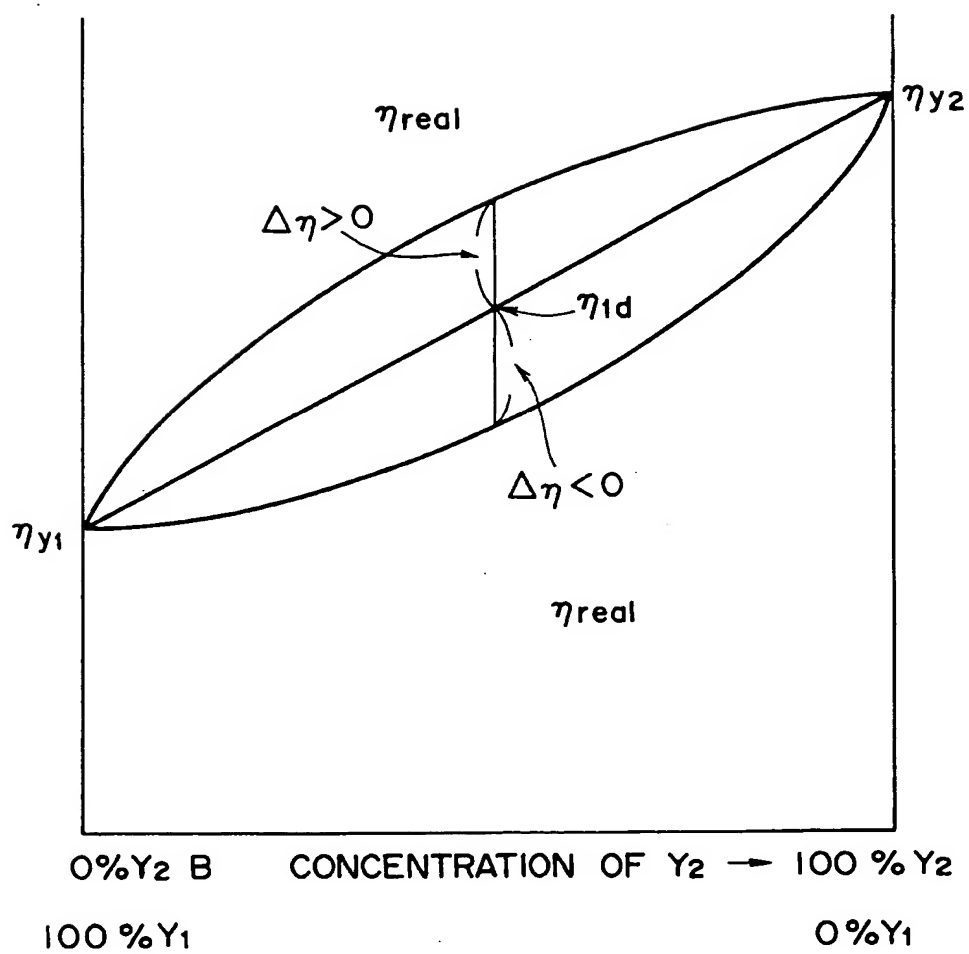
8. A nematic liquid crystal composition according to claim 6, wherein components Y<sub>1</sub> and Y<sub>2</sub> each independently contain at least one compound of the formulae (2) and (4).

9. A nematic liquid crystal composition according to claims 3, 5 and 6, wherein components Y<sub>1</sub> and Y<sub>2</sub> each independently contain a compound of the formulae (2), (3) and (4).

10. A nematic liquid crystal composition according to claims 3, 5 and 6 wherein components Y<sub>1</sub> and Y<sub>2</sub> each independently contain a compound of the formulae (2), (3) and (4).

11. An electrooptical display element using a composition as claimed in any one of the preceding claims.

FIG. 1



**This Page is Inserted by IFW Indexing and Scanning  
Operations and is not part of the Official Record.**

## **BEST AVAILABLE IMAGES**

Defective images within this document are accurate representations of the original documents submitted by the applicant.

Defects in the images include but are not limited to the items checked:

- ☐ **BLACK BORDERS**
- ☐ **IMAGE CUT OFF AT TOP, BOTTOM OR SIDES**
- ☒ **FADED TEXT OR DRAWING**
- ☒ **BLURRED OR ILLEGIBLE TEXT OR DRAWING**
- ☐ **SKEWED/SLANTED IMAGES**
- ☐ **COLOR OR BLACK AND WHITE PHOTOGRAPHS**
- ☐ **GRAY SCALE DOCUMENTS**
- ☐ **LINES OR MARKS ON ORIGINAL DOCUMENT**
- ☒ **REFERENCE(S) OR EXHIBIT(S) SUBMITTED ARE POOR QUALITY**
- ☐ **OTHER:** \_\_\_\_\_

**IMAGES ARE BEST AVAILABLE COPY.**

**As rescanning these documents will not correct the image problems checked, please do not report these problems to the IFW Image Problem Mailbox.**